

# Zero Emission Drayage Truck Demonstration (ZECT I)



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**South Coast Air Quality Management District**

**2017 DOE Vehicle Technologies Office Annual Merit Review**

**June 7, 2017**

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**South Coast  
Air Quality Management District**

**Project ID#  
GI115**

# Overview

## Timeline

- Project start date: Oct. 2012
- Project end date: Sept. 2017\*  
\*1-year extension in process

## Budget

- Total project cost: \$9,374,641
  - ✓ DOE share: \$4,169,000 (45%)
    - \$3,615,850 expended
  - ✓ Cost share: \$5,205,641 (55%)

## Barriers & Targets

- Evaluate performance and reliability
- Promote market acceptance
- Data collection and analysis

## Partners

- SCAQMD
- TransPower
- U.S. Hybrid
- NREL
- TTSI & other fleets



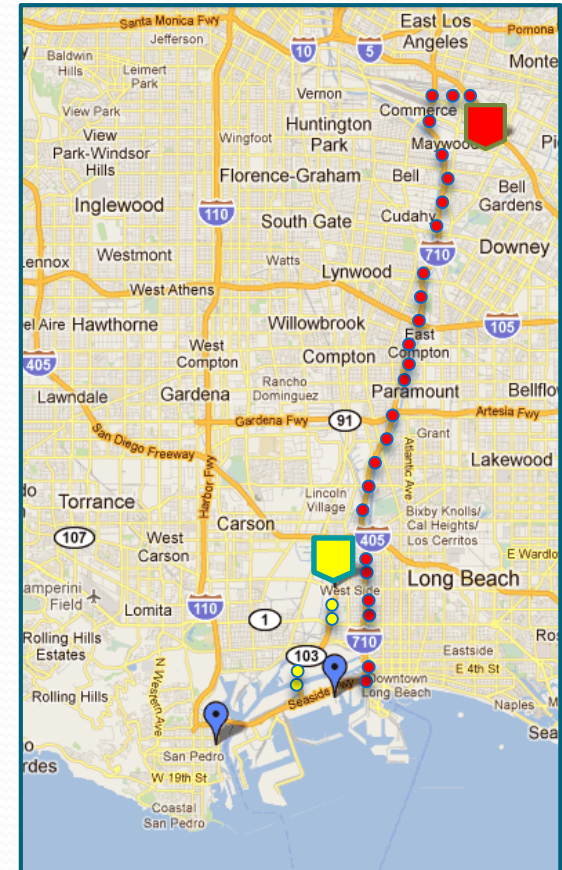
# Objectives

- Evaluate performance and reliability of zero-emission capable heavy-duty trucks in real world drayage operation
- Promote market acceptance through demonstration with fleet partners
- Collect and analyze performance and operational data



# Project Approach/Scope

- Develop 11 Class 8 electric drayage trucks consisting of:
  - Six battery electric trucks (BETs):  
TransPower (4), US Hybrid (2)
  - Five plug-in hybrid electric trucks (PHETs):  
TransPower (2), US Hybrid (3)
- At least one truck from each technology tested on chassis dynamometer to validate vehicle performance
- Up to two years of demonstration in port drayage service with fleet partners
- Collect and analyze performance and operational data against baseline trucks



# Demonstration Technologies

	BET		PHET	
Developer	TransPower	US Hybrid	TransPower	US Hybrid
No. of Trucks	4	2	2	3
Chassis	International Prostar	International Prostar	International Prostar	Peterbilt 384
Traction Motor	Dual IPM Motor 300 kW	Induction Motor 320 kW	Dual IPM Motor 300 kW	PM Motor 223 kW (403 kW combined)
Transmission	Automated Manual	Direct Drive	Automated Manual	Automatic
APU	N/A	N/A	3.7L CNG	8.9L LNG
Battery/Storage Capacity	215 kWh/ 311 KWh	240 kWh	138 kWh/ 60 DGE	80 kWh/ 72 DGE
Charger	On-board ICU 70 kW	On-board 60 kW	On-board ICU 70 kW	On-board 20 kW
Recharge/Refuel Time	2.5-4 hrs	3-4 hrs	2 hrs/ 10-15 min	3-4 hrs/ 10-15 min
Drayage Range	75-100 miles/ 110-150 miles	70-100 miles	250+ miles/ 35-50 AER miles	250+ miles/ 30 AER miles



# Technical Accomplishments and Progress

## BETs - TransPower

- Maintained three Electric Drayage Demonstration trucks (EDDs) in drayage service
  - EDD2 (3Rivers)
  - EDD3 (Cal Cartage)
  - EDD4 (NRT)
- Near dock and local operations within 20-mile radius from ports
- Collectively logged 22,700 miles as of 12/31/16
- Positive feedback on quiet and smooth operations with sufficient power and torque
- Resolved early integration issues and software glitches

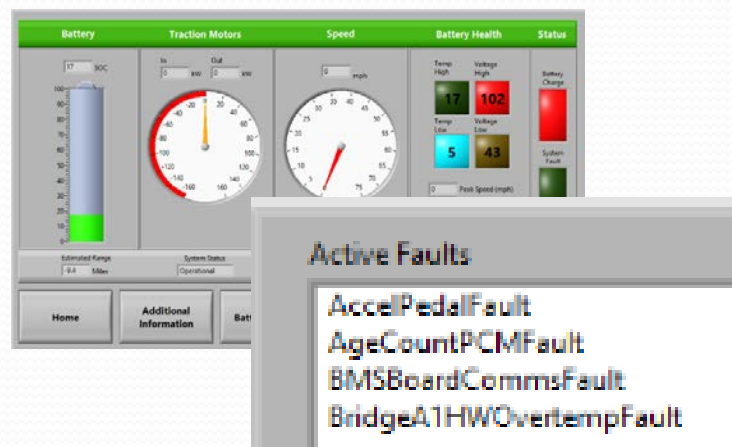


EDD2 – EDD4

# Technical Accomplishments and Progress

## BETs – TransPower (continued)

- Enhanced fault detection and diagnosis for improved reliability and customer support
  - Evolving telemetric data analysis capability
  - Touchscreen Driver Interface
- EDD1 upgrade completed in Q1 2017
  - 60% higher energy density cells
  - Advanced BMS with active cell balancing
  - 50% improvement in operating range (110-150 miles)
  - Undergoing validation testing



Touchscreen Driver Interface



Upgraded EDD1

# Data Collection & Analysis

## BETs

- 1/15 through 12/16
- EDD 2, 3 & 4
- 488 days of operation
- 22,700 miles traveled



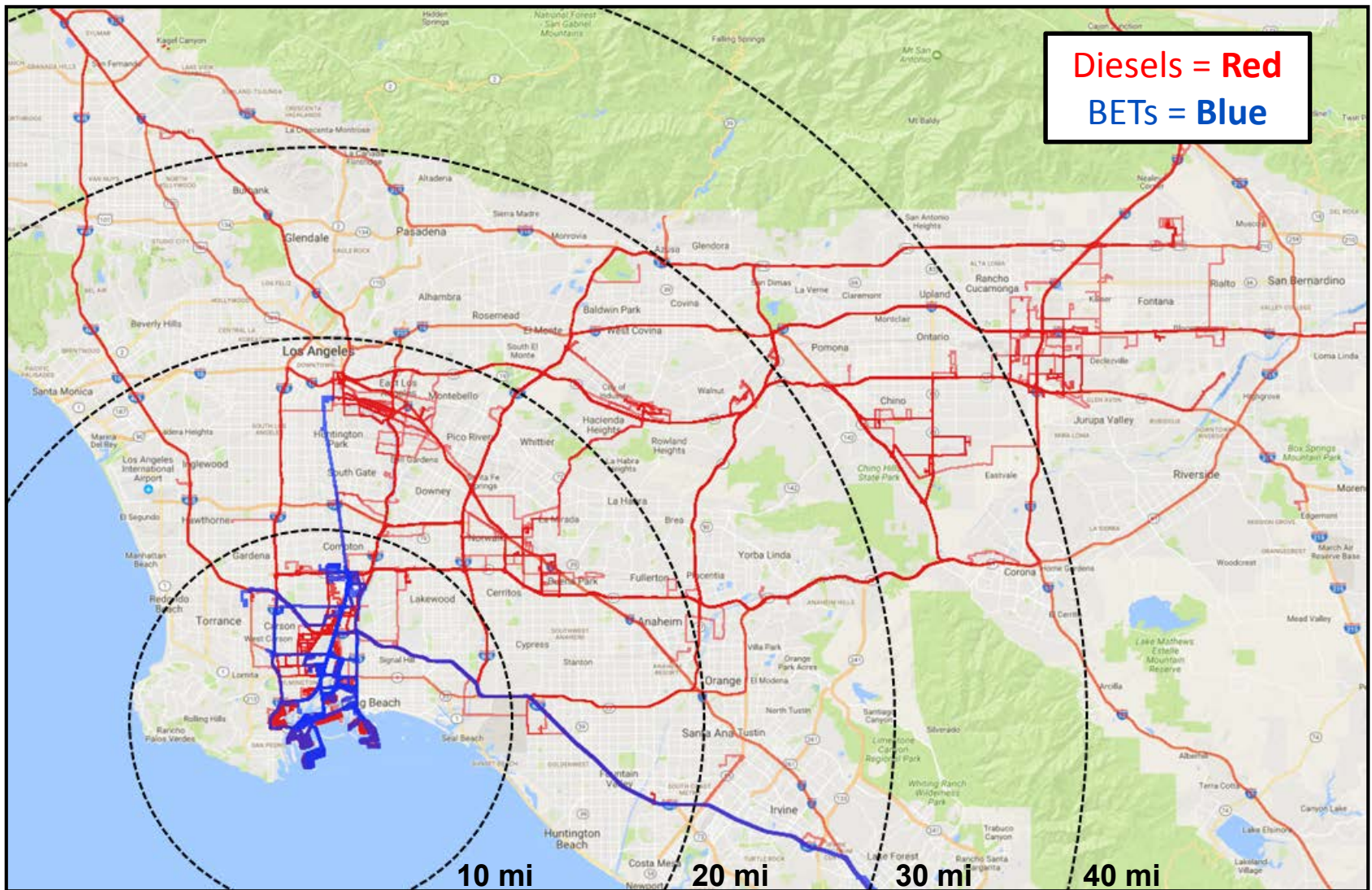
## Baseline Diesel

- 10/14 and 8/15 (24 wks)
- 30 diesel trucks
- 577 days of operation
- 71,200 miles traveled

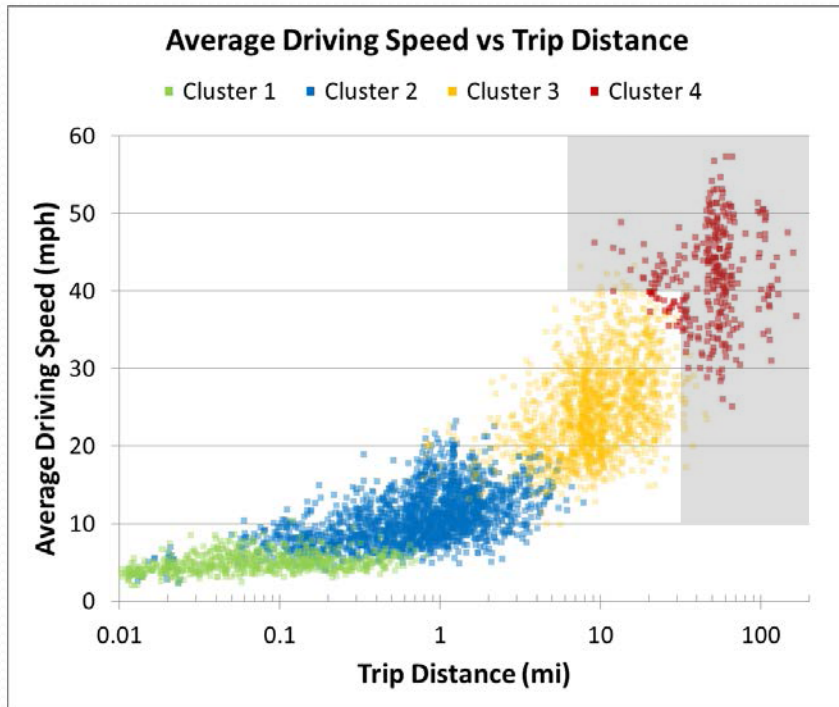




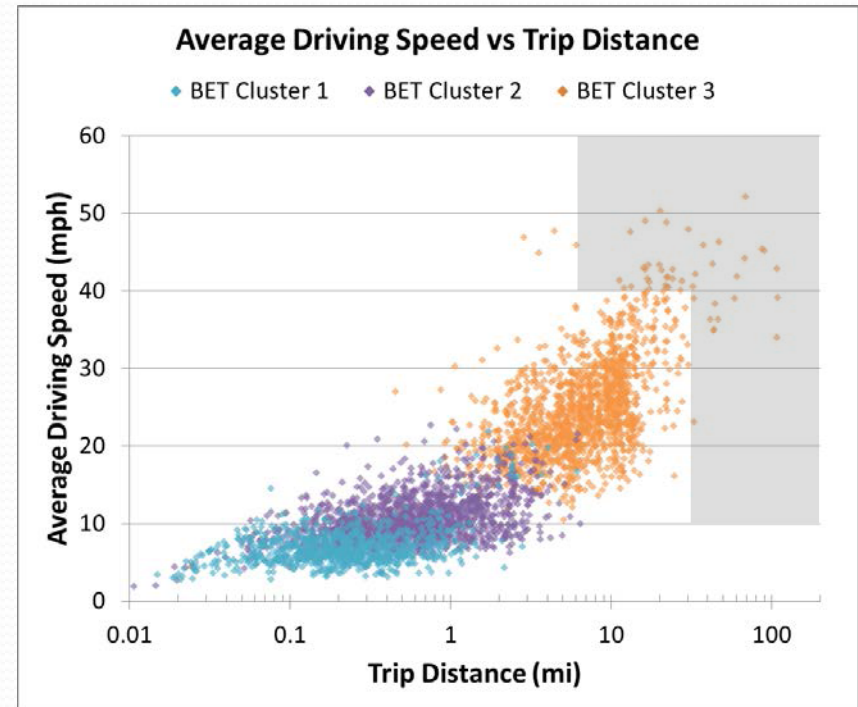
# Range of Operations



# Trip Kinematics by Cluster



Conventional  
Diesels



BETs

# Average Daily Use

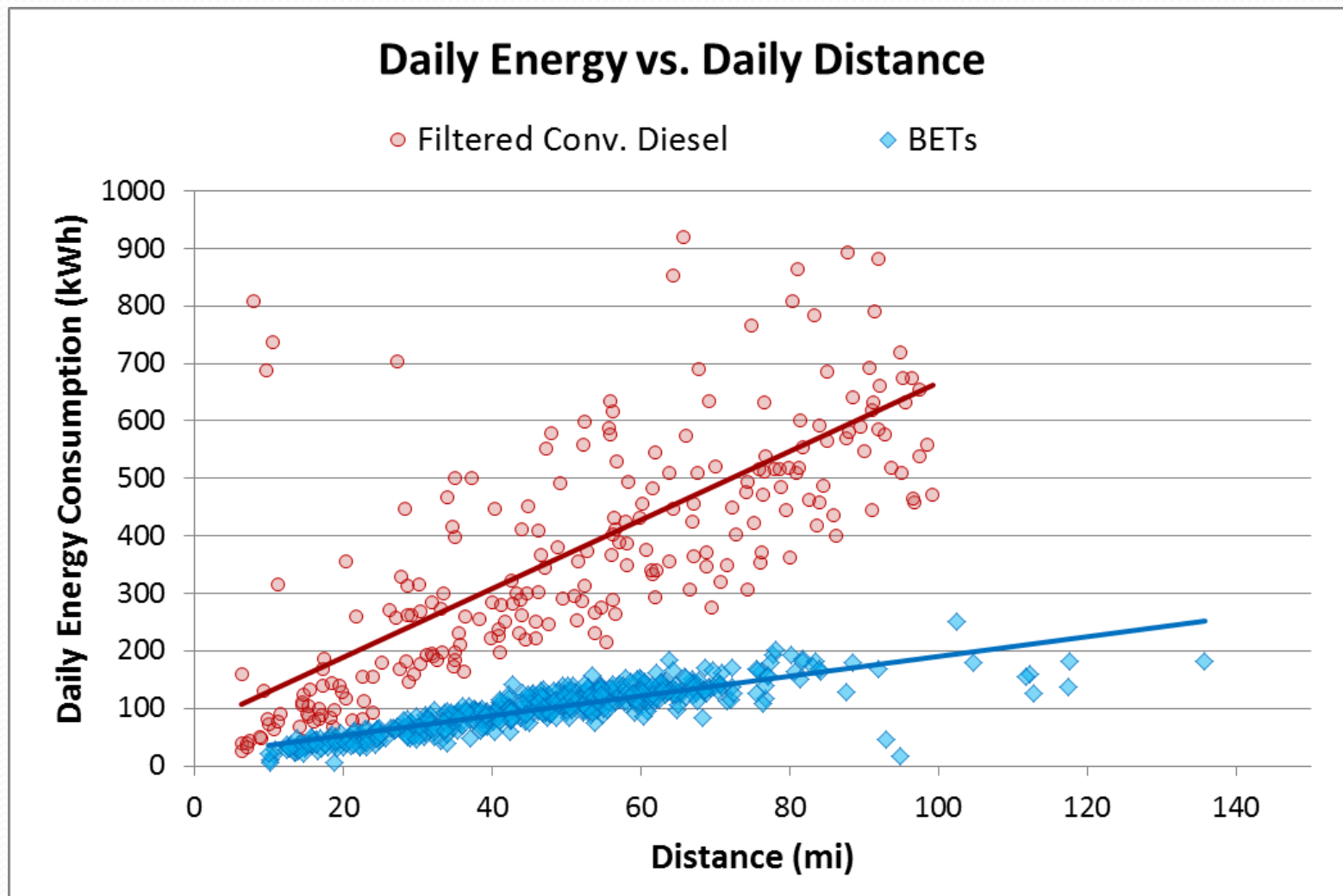
	BETs <sup>1</sup>	COV	Conv. Diesel Filtered <sup>3</sup>	COV
Number of Days	488	N/A	252	N/A
Operational Time (hr)	5.33	44%	6.02	85%
Idle/Stationary Time (hr)	2.98	56%	3.67	126%
Daily Distance (mi)	46.47	43%	52.26	51%
Average Driving Speed (mph)	20.11	26%	22.45	18%
Average Total Speed (mph)	9.73	50%	11.25	46%
Kinetic Intensity (1/mi)	1.19	36%	0.85	52%
Efficiency (kWh/mi)	2.17	19%	6.64 <sup>2</sup>	109%
Fuel Economy (MPG <sub>de</sub> )	18.62 <sup>2</sup>	57%	5.67	32%
Regen Energy (kWh)	17.92	53%	N/A	N/A
Remaining SOC (%)	52.90	34%	N/A	N/A

<sup>1</sup> Includes vehicles: EDD2, EDD3, EDD4 through 12/31/16

<sup>2</sup> kWh/mi and MPG<sub>de</sub> calculated using 37.656 kWh / gallon of diesel fuel

<sup>3</sup> Filtered days exclude days with distance >100mi and Avg. driving speed >40 mph

# Daily Energy Consumption





# Technical Accomplishments and Progress

## BETs – US Hybrid

- First of two BETs deployed with TTSI in Q3 2016
- With EVSE out of service, BET #1 is not in commercial use
- TTSI in process of installing EVSEs at new location near Port of LA
- Delay in permitting but installation expected by early Q2 2017
- US Hybrid selected A123 as new battery supplier
- BET #2 to be completed in Q2 2017



US Hybrid BET#1

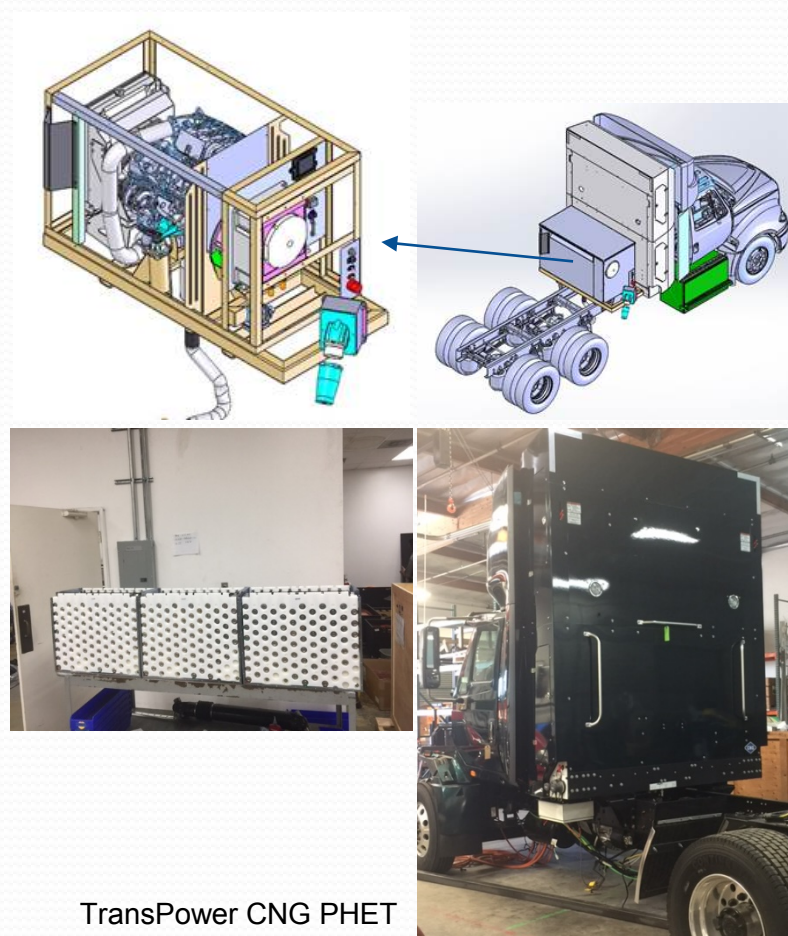


US Hybrid BET #2

# Technical Accomplishments and Progress

## PHETs - TransPower

- Funded in 2015
- Series hybrid architecture based on EDD drive train
- Undergoing hybrid system optimization with APU dynamometer
- Emissions measurement scheduled with UCR
- Battery modules to be tested for capacity with AV900
- First PHET to be completed by Q2 2017



TransPower CNG PHET

# Technical Accomplishments and Progress

## PHETs – US Hybrid

- Funded in 2015
- Parallel hybrid design to convert LNG trucks with 8.9L ISLG engine
- Comparable power and torque to Cummins ISX 12 and ISX 15
- First PHET tested at UCR chassis dynamometer facility
- Two trucks delivered to TTSI in Q1 2017 for deployment
- Third PHET to be completed in Q2 2017



US Hybrid PHET Chassis Dyno Testing at UCR



US Hybrid PHETs at TTSI

# Proposed Future Work

- Remainder of FY 16-17
  - BETs
    - Continued demonstration for TransPower EDD2 – EDD4
    - US Hybrid to resume demonstration with first BET, and deploy second BET
    - TransPower to re-deploy upgraded EDD1
  - PHETs
    - Begin demonstration for two US Hybrid PHETs
    - US Hybrid to complete third PHET
    - TransPower to complete and deploy first PHET
- FY 17-18
  - TransPower to deploy last PHET by Q1
  - Complete demonstration by Q4

Any proposed future work is subject to change based on funding levels



# Response to Reviewer Comments

- One reviewer commented that these vehicles reduce petroleum, but the cost is significant.

Response: It is premature to compare the cost to conventional diesel trucks. The cost will be significantly reduced once these technologies have matured and reach wide-scale deployment. For example, the battery cost has dropped sharply with a growing EV market.

- One reviewer questioned what metrics will be used to assess the success of the technologies.

Response: The main objective of this project is to evaluate the performance and reliability of electric truck technologies in real world drayage service. Operational data collected during the demonstration will be analyzed and compared against baseline diesel trucks to assess technical feasibility. Also, chassis dynamometer testing by a third party will evaluate the performance and capability of the electric trucks. Finally, survey of operators and drivers will provide valuable feedback on market acceptance and improvements needed toward future commercialization.

# Collaboration and Coordination

- TransPower and US Hybrid each to develop Class 8 BETs and PHETs for demonstration in drayage service
- University of California, Riverside to perform chassis dynamometer testing of demonstration vehicles
- TTSI and other fleet partners to deploy demonstration vehicles in drayage service
- NREL to analyze vehicle performance and operation data during the demonstration



# Summary

## Objective

- Demonstrate zero-emission capable trucks in real world drayage service to evaluate performance and reliability, and to promote market acceptance

## Approach

- Develop a total of eleven demonstration trucks consisting of:
  - Six BETs: TransPower (4), US Hybrid (2)
  - Five NG PHETs: TransPower (2), US Hybrid (3)
- Chassis dynamometer testing to validate vehicle performance
- Up to two years of demonstration in drayage service
- Collect and analyze performance and operational data against baseline diesel trucks

# Summary (Continued)

## Technical Accomplishments

- TransPower maintained three BETs (EDD2 – EDD4) in drayage service with fleet partners
- US Hybrid completed and deployed first BET and two PHETs
- TransPower nearing completion of first PHET

## Future Work

- TransPower to re-deploy upgraded EDD1
- US Hybrid to deploy second BET and third PHET in Q2 2017
- TransPower to complete both PHETs by Q4 2017